RESEARCH, DEVELOPMENT and TECHNOLOGY TRANSFER QUARTERLY PROGRESS REPORT (QPR)

Wisconsin Department of Transportation (WisDOT)
DT1241 5/2014

INSTRUCTIONS:
Research principal investigators and/or project managers should complete a quarterly progress report (QPR) for each calendar quarter during which the projects are active.

WisDOT Research Program Category	Report Period *(enter year and check which quarter)*	
☐ Policy Research ☒ Wisconsin Highway Research Program ☐ Other: ______	Year: 2014 ☐ Quarter 1 (Jan 1 – Mar 31) ☐ Quarter 2 (Apr 1 – Jun 30)	☒ Quarter 3 (Jul 1 – Sep 30) ☐ Quarter 4 (Oct 1 – Dec 31)

Project Title		WisDOT Project ID
Permeability Performance and Lateral Load for Granular Backfill behind Abutments		0092-14-03
Principal Investigator Name Pavana Vennapusa	Project Oversight Committee Chair Name Jeff Horsfall	Project Start Date (m/d/yyyy) 8/13/2013
(Area Code) Telephone Number 515-294-2395	(Area Code) Telephone Number 608-243-5993	Original End Date (m/d/yyyy) 2/12/2015
Email Address pavanv@iastate.edu	Email Address Jeffrey.Horsfall@dot.wi.gov	**Current End Date** (m/d/yyyy) 2/12/2015

Project Schedule Status *(check one)*
☐ On Schedule ☐ On Revised Schedule ☐ Ahead of Schedule ☒ Behind Schedule

Project Budget Status

Total Project Budget	Expenditures Current Quarter	Total Expenditures	% Funds Expended	% Work Completed
$150,000.00	$13,937.22	$101,721.53	68%	70%

Project Description

The current WisDOT Bridge Manual recommends using “pervious” granular backfill behind bridge abutments to prevent lateral water pressures on the abutment walls. The granular backfill material is considered “pervious” or “free-draining” based on its grain-size distribution properties. However, the “free-draining” assumption of granular backfill does not properly consider:

a) granular backfill material properties in terms of its water infiltration capacity, permeability, and water retention characteristics,
b) effect of undrained water on the lateral earth pressures exerted on the abutment walls, and
c) short- and long-term effectiveness of the pipe underdrain.

The specific research objectives of this work are to:

- Identify the current state of the practice of other state DOTs and scholarly articles addressing the influence of granular backfill permeability and water retention characteristics on the lateral earth pressure distribution and short- and long-term effectiveness of the pipe underdrain system, and collect relevant data for use in this research project.
- Conduct a thorough field investigation at 4 sites with structural backfill and granular grade 1 materials as selected by the project Technical Oversight Committee (TOC) to: (a) measure in situ permeability and water retention characteristics of the backfill materials, (b) measure in situ shear strength characteristics of the backfill materials, (c) monitor lateral earth pressures and pore pressures behind abutment walls, and (d) evaluate the performance of the pipe underdrain systems both in short- and long-term.
- Conduct a thorough laboratory investigation of the materials collected from the field sites and the alternative materials including recycled asphalt pavement (RAP) and foundry sand, to determine their shear strength, water retention, and permeability characteristics.

- Develop a practical quantitative approach to analyze lateral earth pressures on abutment walls accounting for water infiltration rate, pore pressure distribution due to infiltrated water flow, performance of pipe under drain, total unit weight, and shear strength characteristics of the backfill material.
- Develop recommendations specific to the current state of the practice of WisDOT's abutment granular backfill design and construction practices, and the impact of using alternative materials (RAP and foundry sand).

The project has been divided into the following five phases: (I) Literature Review, (II) Field and Laboratory Investigations, (III) Analysis and Evaluation of Field and Laboratory Testing, (IV) Evaluation of Alternative Materials, and (V) Final Report.

Progress This Quarter *(includes meetings, work plan status, contract status, significant progress, etc.)*
Significant progress has been made this quarter on all phases of this project. Brief details are provided below.

<u>Phase I:</u> The research team continued collecting relevant literature on this research. One important component of this research is to provide Wisconsin DOT a simple analytical approach to assess drainage in the backfill materials. The team is investigating an approach proposed by Casagrande and Shannon (1952), for determining time for drainage under pavements based on scaled laboratory tests. The approach is simple and requires inputs of hydraulic conductivity, cross-sectional details (width and depth of backfill), porosity of backfill, and material specific constant values. Laboratory tests are underway to validate the approach and develop material specific constant values.

<u>Phases II and III:</u>

Field Testing:

Field testing and instrumentation was conducted on Schwartz Road Bridge in Oconto County, WI (Project #2) on September 5, 2014. The project site received 4 in. of rain prior to our arrival and the water level in the creek was near the maximum water level indicated in the plans. Ponding with nearly 2 to 3 ft of water was observed in both abutment excavations (Figure 1). Water was pumped out by the contractor and some of the soft subgrade at the bottom of the excavation was removed. ISU research team conducted dynamic cone penetrometer (DCP) tests at the bottom of the excavation and at the top of the backfill after all lifts are placed. Results are shown in Figure 2. DCP tests within the top 6 to 12 in. of the bottom of the excavation indicated very soft conditions, while in the backfill indicated increasing CBR values with depth due to confinement. Air permeability tests (APTs) were also conducted on the backfill material, which showed a saturated hydraulic conductivity of 0.09 cm/s (255 ft/day). The material was comparatively less permeable than the structural backfill material used in the Slovak Valley Creek Bridge on SH79 in Boyceville (Project #1). Gradation properties of the backfill materials from the two projects are shown in Figure 3. Material from the Schwartz Road bridge project consisted of more

Analysis of field results from the first project (Slovak Valley Creek Bridge in Boyceville) indicated variations in earth pressures over time. This prompted investigating potential movement of bridge abutment due to temperature variations to explain the variations in earth pressures. The research team has decided to place tilt meters and long-range displacement sensors on the remaining three projects to monitor these movements. The Schwartz road bridge included two tilt meters to monitor movements and determine angle of tilt on one abutment and a long-range displacement sensor connected to both abutments to monitor relative movements.

Laboratory Testing:

Laboratory classification tests (grain-size), and Proctor and vibratory compaction tests were performed on the backfill material obtained from the Schwartz Road Bridge and the results are being analyzed. Collapse tests were performed on Slovak Vally Creek Bridge backfill material using a Consolidometer with controlled overburden stresses. The tests were performed with a 1 psi seating pressure for 2 minutes and then overburden pressures of 4 psi, 8 psi, and 16 psi were applied for 2 minutes. After 2 minutes, water was introduced and change in axial strain was monitored to assess collapse. Results from this testing in comparison with compaction test results are shown in Figure 4. Collapse was maximum when the moisture content of the material was at 3% (note that field moisture content ranged between 3% to 5%). Collapse increased from about 0.1 to 0.8% as the overburden stress was reduced from 16 to 4 psi. Collapse decreased with increasing moisture contents to about zero at about 7%, which is close to standard Proctor optimum moisture content. This emphasizes the importance of compacting backfill materials in wet condition. Similar tests are underway for Shwartz Road Bridge material.

Scaled abutment model testing was performed on the materials obtained from the two project sites. The abutment model was first tested with pea gravel as backfill material to assess its capacity to drain water and establish a base line reading with changes in pore pressure in the backfill material. APT and corehole permeability (CHP) tests are being performed on the backfill material first, then the material is being saturated by filling the model with water with drains closed, and then the drains are opened to assess the time it takes for the water to drain out. Dynamic pore pressure sensors are installed in the abutment model (one near the drain and one near the back edge of the backfill) to monitor the change in pore pressures. Some pictures of abutment model testing are shown in Figure 5. Preliminary results of pore pressure dissipation with time for pea gravel and Slovak Valley Creek Bridge backfill material are shown in Figures 6 and 7. The results are currently being analyzed.

<u>Phase IV:</u>

As part of evaluating alternative materials for bridge backfill in Wisconsin, recycled asphalt pavement (RAP) and recycled asphalt shingles (RAS) materials were obtained from Mathy Construction Co. quarries near Onalaska, WI. Lab testing on these materials is underway. RAP material met the DOT gradations for structural backfill, but the RAS material did not. RAS material contained about 16% of fines. Material processing is underway to re-grade it to structural backfill gradation requirements. Testing planned on these alternative materials include, shear strength testing, permeability testing (with variying fines content to assess influence of fines), collapse potential and axial strain tests. Preliminary testing conducted on RAP material indicated axial strains of up to 10% due to particle crushing and rearrangement although collapse was not significant. The axial strains reduced with increasing moisture content. More results will be provided in the next quarter.

Anticipated Work Next Quarter

The following activities are anticipated during the next quarter:

Two additional bridge sites will be field tested and instrumented next quarter. These bridges include:

1. Badger Road over Branch Martin Branch in Grant County, WI – Scheduled for October first week.
2. Hobbles Creek Road over Hobbles Creek in Price County, WI – Scheduled for October last or November first week.

Additional tasks include:

1. Continue laboratory testing and analyze field instrumentation results.
2. Perform laboratory bridge abutment model tests using material bridge sites to calibrate numerical models.

Circumstances Affecting Project or Budget

During the proposal phase, it was anticipated that field work at all bridges will be completed during summer 2014 so that field instrumentation data can be analyzed in the Fall to meet the November 30th deadline to submit report to TOC. However, only two bridges were completed so far and there are two more bridges that need to be instrumented and tested and relevant laboratory testing on those materials need to be completed. Because of this, the final report cannot be submitted by November 30th, 2014. We request that the report deadline be extended to end February 2015 and the project end date be extended to May 30, 2015.

Figure 1. Pictures showing ponding in backfill excavation due to rain on Schwartz Road Bridge in Oconto County

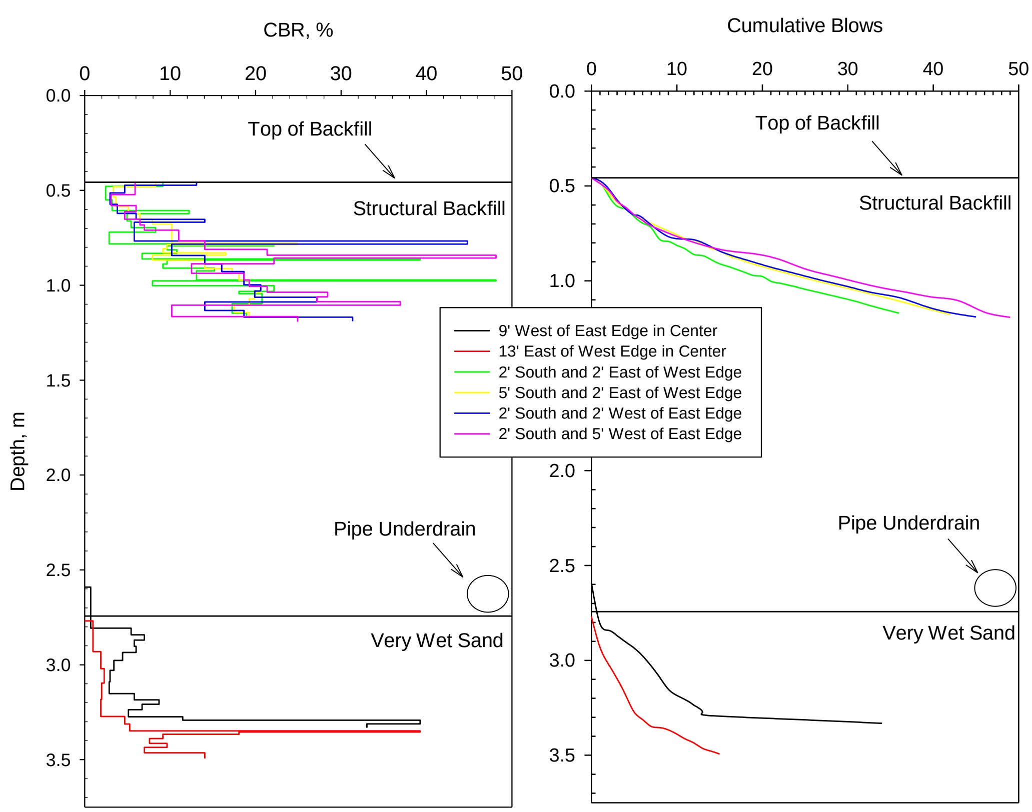


Figure 2. DCP test results for Schwartz Road Bridge located in Oconto County

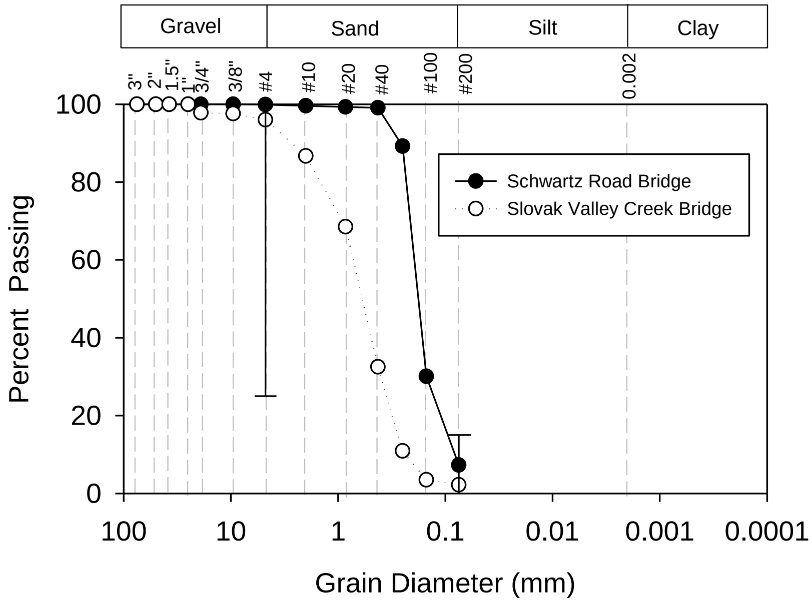
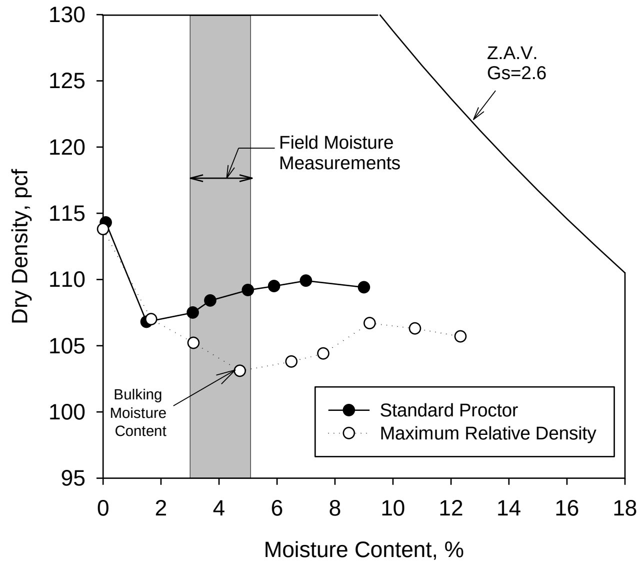
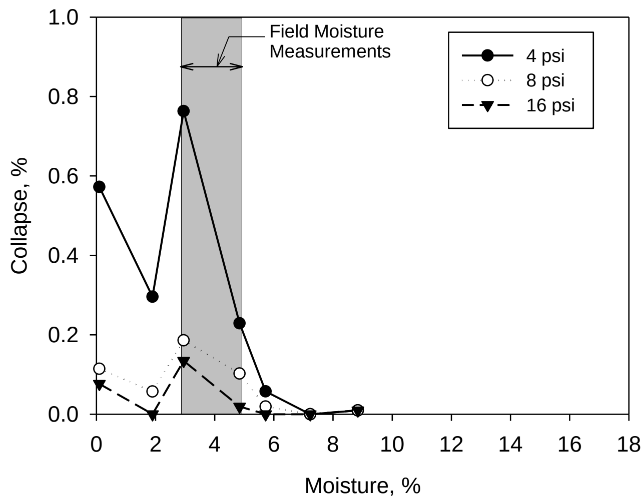


Figure 3. Gradation Results for Schwartz Road Bridge in Oconto County and Slovak Valley Creek Bridge in Boyceville



(a)



(b)

Figure 4. Laboratory test results on Slovak Valley Creek Bridge backfill material with (a) compaction tes results and (b) collapse test results

Figure 5. Pictures of testing in scaled abutment model using pea gravel as backfill material

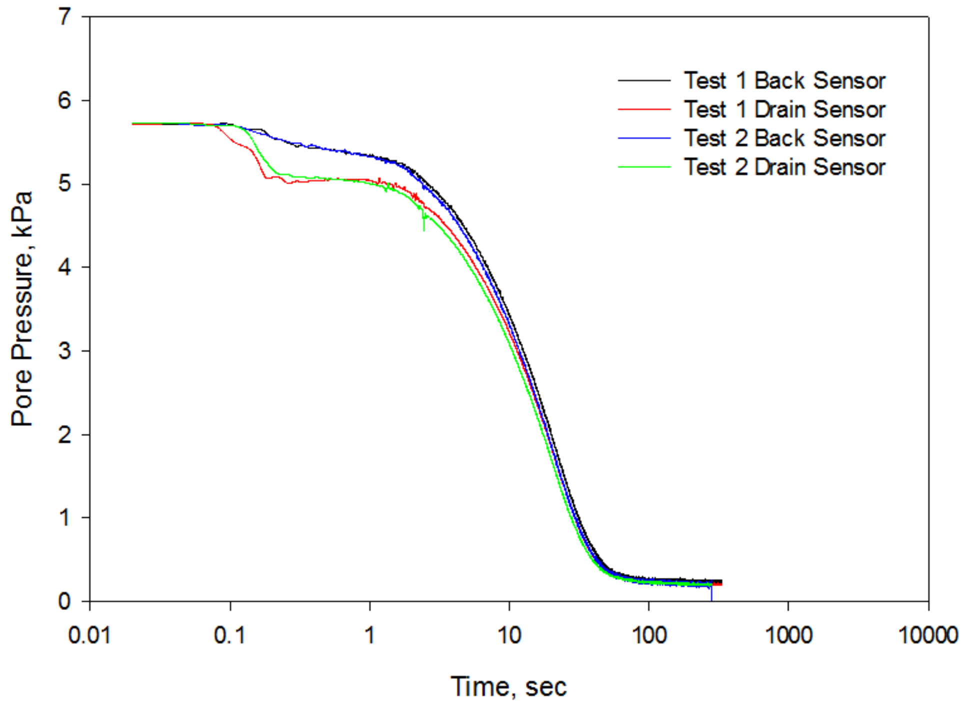


Figure 6. Pore Pressure Dissipation for Pea Gravel

Attach / Insert Gantt Chart and Other Project Documentation

	MONTH																		
	Aug-13	Sep-13	Oct-13	Nov-13	Dec-13	Jan-14	Feb-14	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15
Phase I																			
Phase II																			
Phase III																			
Phase IV																			
Phase V																			
TOC Review, Revision, and Final Submission																			

*(*enter text)*

For WisDOT Use Only	
Staff Receiving QPR J. Walejko	Date Received (m/d/yyyy) 10/9/2014
Staff Approving QPR Jeff Horsfall	Date Approved (m/d/yyyy) 10/24/2014